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(54) **ELECTRICAL MOTOR**

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(58) **Field of Classification Search**
CPC H02K 5/20; H02K 9/19; H02K 11/0089; H02K 9/24; H02K 9/20
USPC .... 310/58, 60 A
See application file for complete search history.

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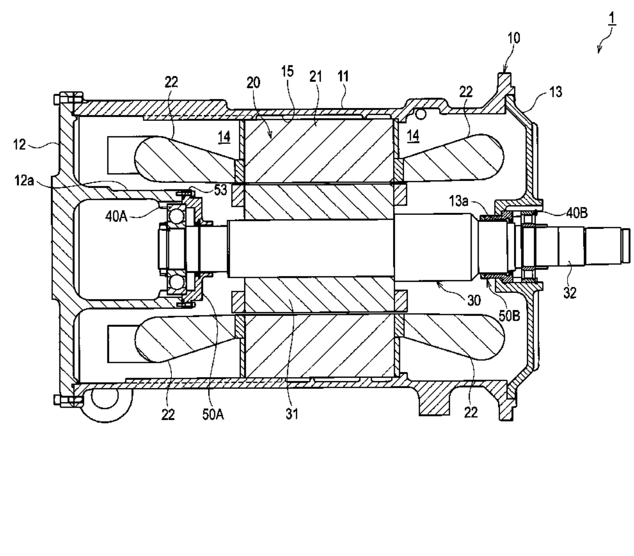
(57) **ABSTRACT**

An electrical motor includes a motor case inside which an inner space is formed, a bearing disposed so as to pass through a wall of the motor case, a rotor shaft rotatably supported by the bearing, and an earth conductor fixed with the motor case and provided with a frame and an electrical conductor provided on the frame. The frame has an annular inner circumferential surface along an outer circumference of the rotor shaft and is fixed with the motor shaft. The electrical conductor is disposed on the inner circumferential surface of the frame so as to slidably contact its end with the rotor shaft. A bypass flow passage is provided between the earth conductor and the motor case. The inner space is communicated with an outside of the motor case via the bypass flow passage. According to the motor, its inside can be cooled without damaging the earth conductor.

5 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

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H02K 5/173	(2006.01)
H02K 11/00	(2006.01)
H02K 9/24	(2006.01)
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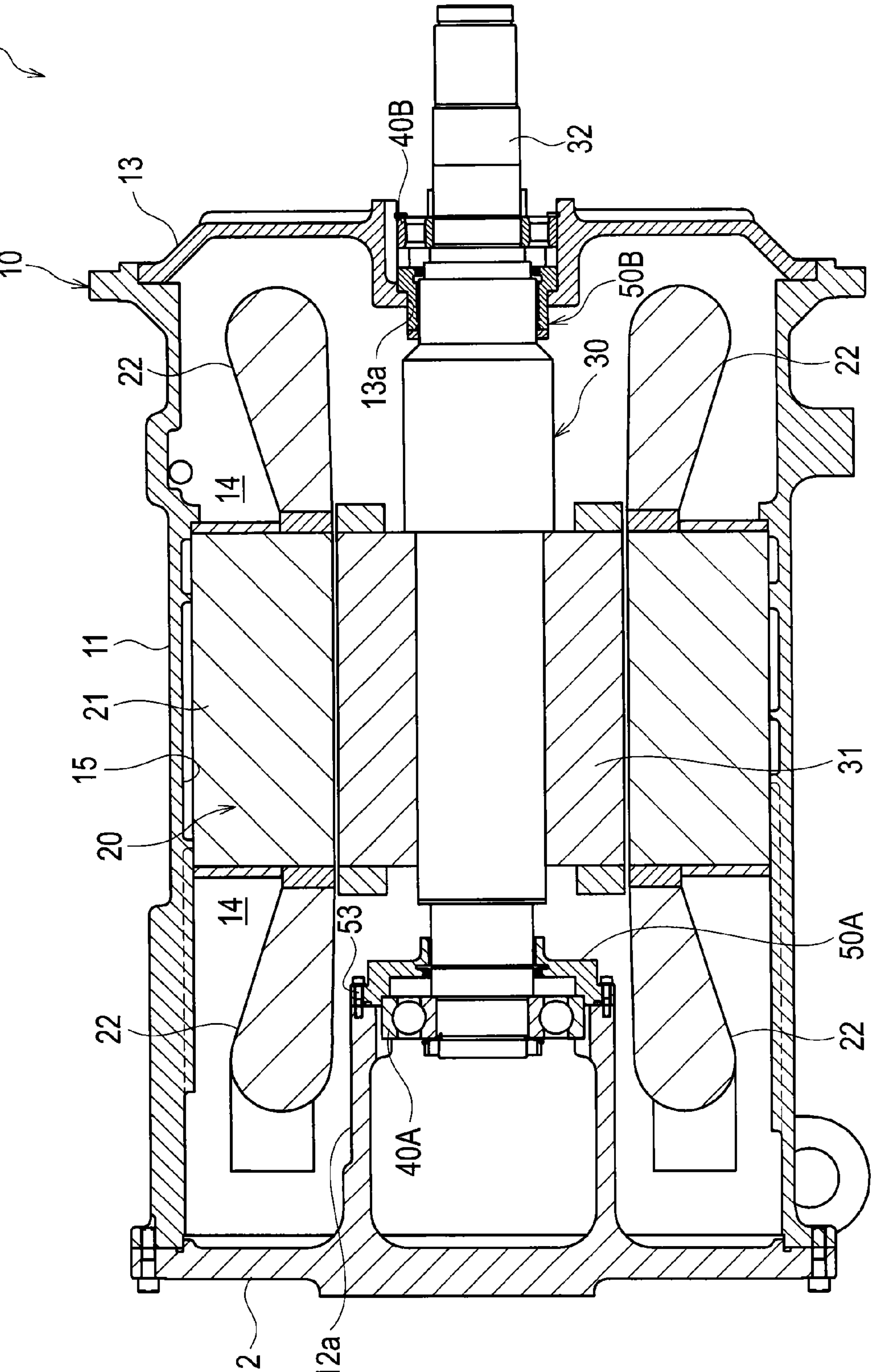
FIG. 1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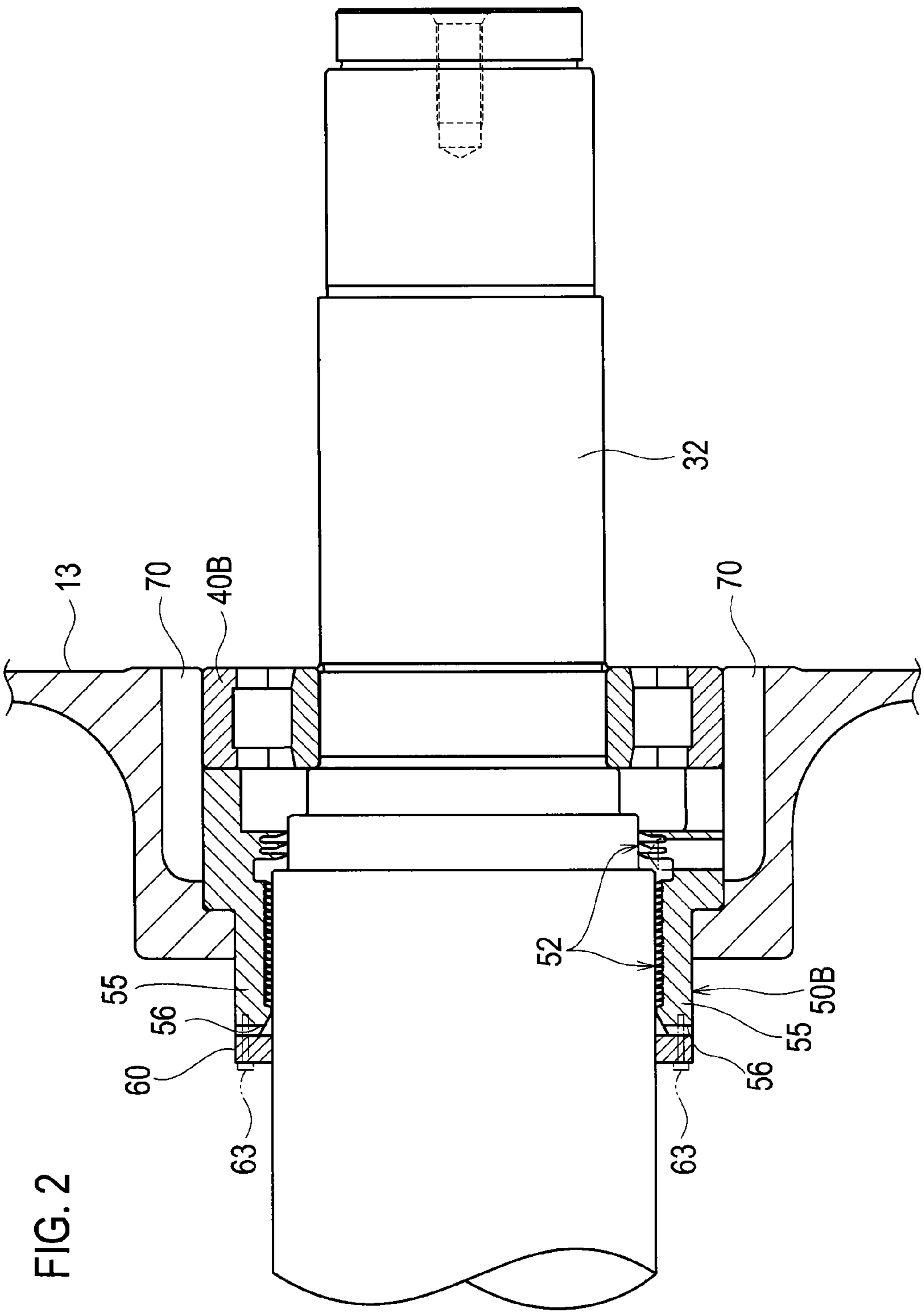


FIG. 2

FIG. 3

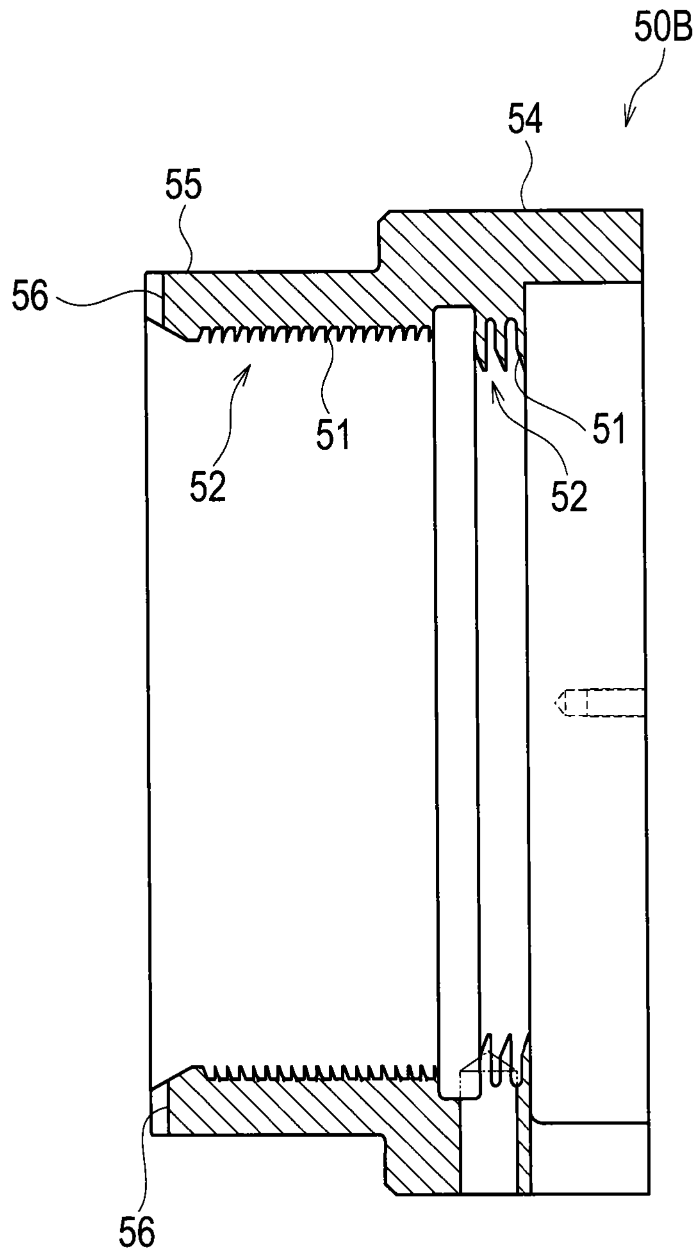


FIG. 4

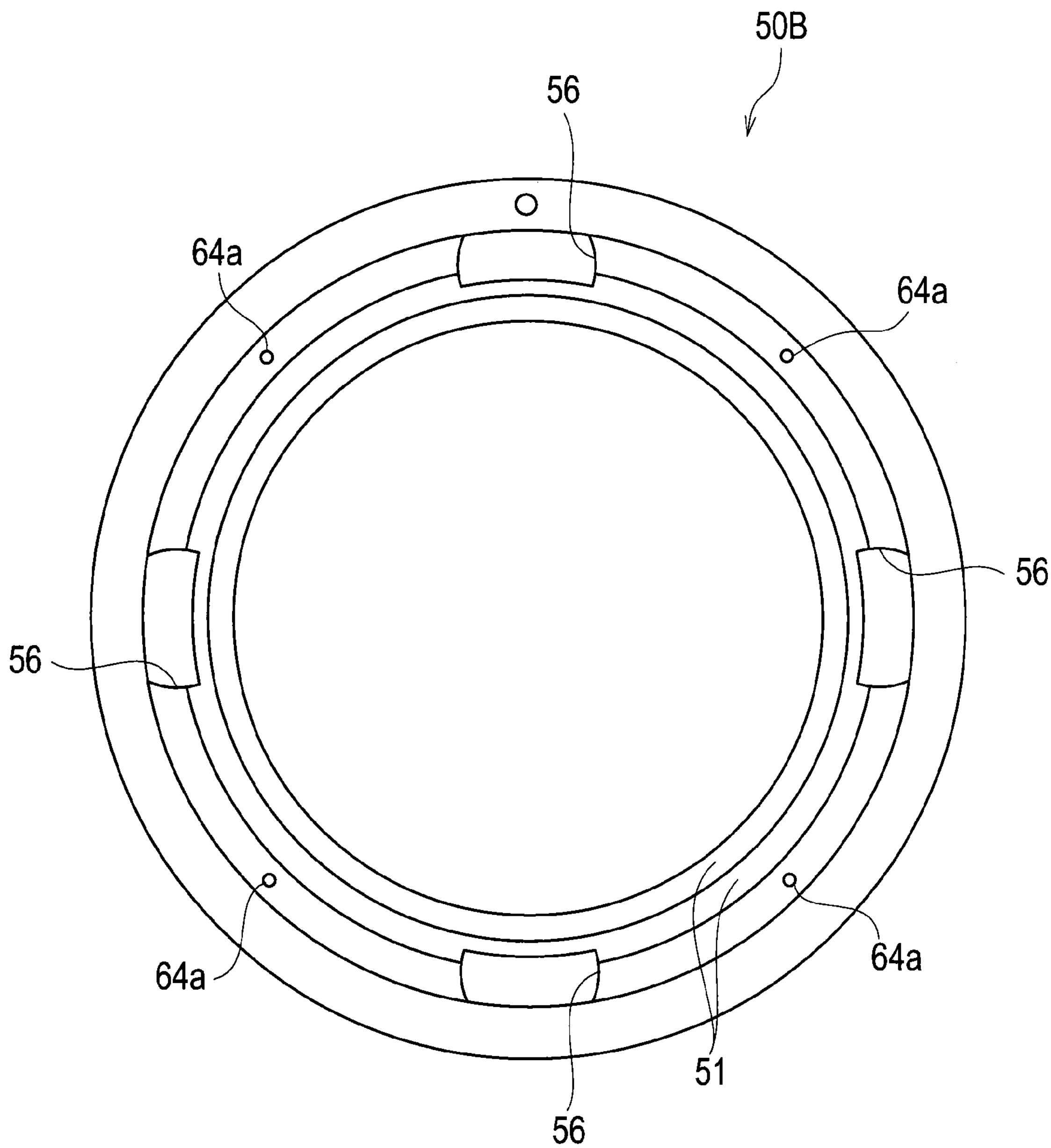
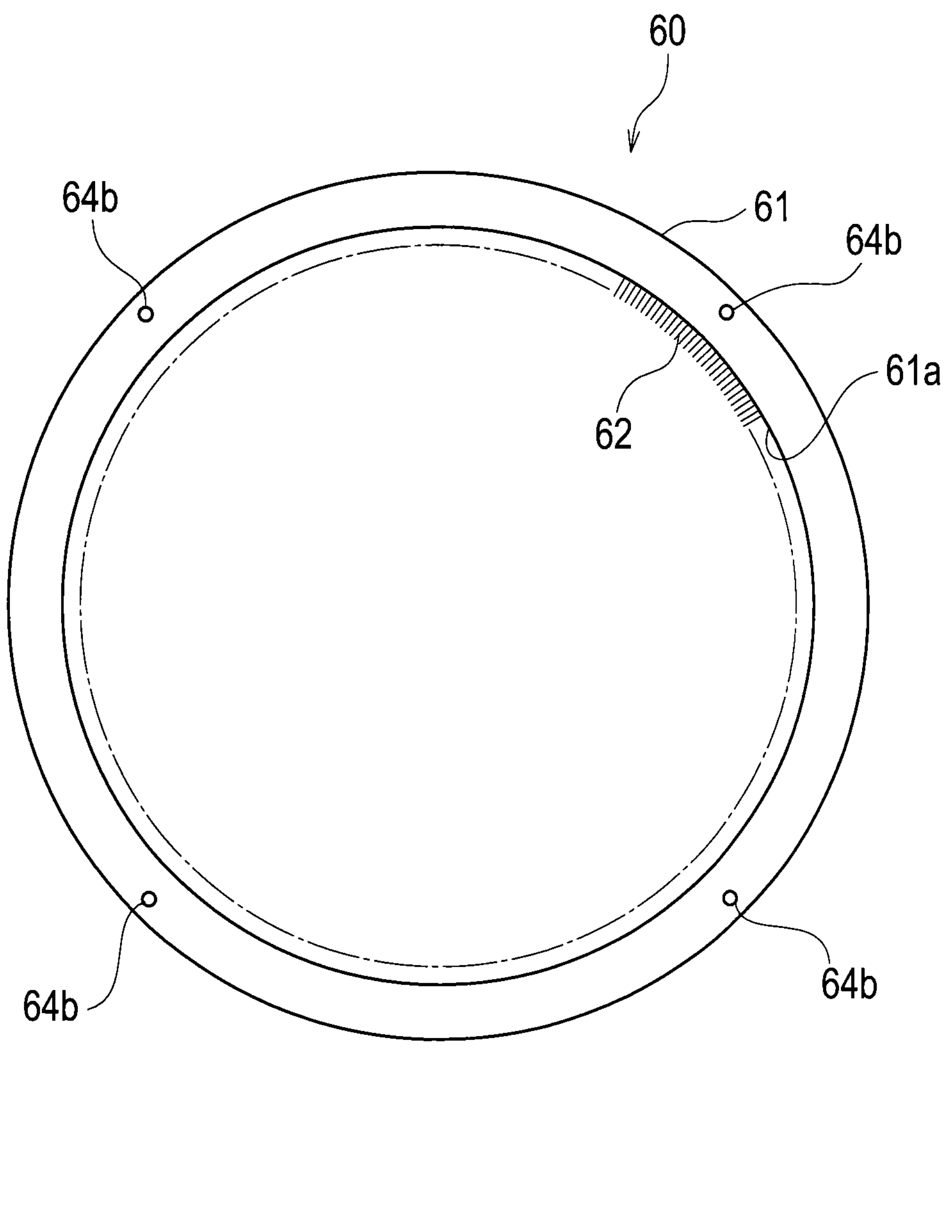


FIG. 5



ELECTRICAL MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a Continuation Application of PCT International Application No. PCT/JP2012/067338 (filed on Jul. 6, 2012), which is based upon and claims the benefit of priority from Japanese Patent Application No. 2011-154720 (filed on Jul. 13, 2011), the entire contents of which are incorporated herein with reference.

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to an electrical motor that is driven while its rotational speed is variably controlled.

2. Background Art

Conventionally, rotational speed of an electrical motor is controlled by using an inverter. However, shaft current flows through a rotor shaft of the electrical motor due to a pulse wave of output voltage from the inverter, and thereby discharges occur in a bearing(s) when the shaft current flows to a motor case through the bearing. There is a disadvantage that the bearing may be made electrically corroded by these discharges. In order to prevent such electrical corrosions, it is done to flow electrical charge remained in the rotor shaft to the motor case without flowing it through the bearing by using an earth conductor. Patent Documents 1 (Japanese Granted Patent Publication No. 4485897) and Patent Document 2 (PCT International Application Japanese Translation Publication No. 2010-525787) disclose such an earth conductor. In such an earth conductor, its annular frame is fixed to a motor case, and a rotor shaft is inserted through the annular frame. In addition, many fiber-like conductors are mounted on an inner surface of the annular frame toward the rotor shaft, and distal ends of the fiber-like conductors are contacted with the rotor shaft. According to this configuration, the electrical charge remained in the rotor shaft flows to the motor case through the fiber-like conductors.

SUMMARY OF INVENTION

Since an electrical motor is highly-heated due to a long time drive or a large load, it may be provided with a cooling mechanism for cooling its inside. Known is a cooling device that sprays refrigerant liquid to an inside of a motor for cooling by vaporization heat. In a case of using such a cooling device, inside pressure of the motor rises higher than outside pressure due to vaporization of the refrigerant liquid, and thereby the vaporized refrigerant may leak out from a gap between a motor case and a rotor shaft or a gap between the rotor shaft and a bearing(s). The above-explained fiber-like conductors as an earth conductor are fluttered by a flow of the refrigerant gas that leaks out, so that their degradations are accelerated and then they are lost. The lost fiber-like conductors cannot only fulfill its original function, but also may cause problems such as stuck into the bearing and commixture into lubrication oil as impurities.

An object of the present invention is to provide an electrical motor that can cool its inside without damaging its earth conductor.

An aspect of the present invention provides an electrical motor comprising: a motor case inside which an inner space is formed; a bearing disposed so as to pass through a wall of the motor case; a rotor shaft rotatably supported by the bearing; and an earth conductor that is fixed with the motor case

and includes a frame and an electrical conductor provided on the frame, wherein the frame has an annular or curved inner circumferential surface along an outer circumference of the rotor shaft and is fixed with the motor case, the electrical conductor is disposed on the inner circumferential surface of the frame so that an end of the electrical conductor is slidably contacted with the rotor shaft, a bypass flow passage is provided between the earth conductor and the motor case, and the inner space and an outside of the motor case are communicated with each other via the bypass flow passage.

According to the above electrical motor, pressure of fluid used for cooling its inside rises higher than outside pressure due to heat, and thereby flows out from the motor case through the bypass flow passage, instead of through a gap between the earth conductor and the rotor shaft that provides larger flow resistance. Therefore, when cooling the inside of the electrical motor (motor case), it is possible to control the electrical motor using an inverter (variable frequency control) without damaging the electrical conductor.

Here, if the inner space is filled with higher-pressure gas than pressure outside the motor case, the above-mentioned fluid is changed from refrigerant liquid to refrigerant gas in the electrical motor (motor case) and thereby the refrigerant gas prominently flows out from the inside of the electrical motor (motor case) to the outside thereof. However, as mentioned above, since the refrigerant gas flows out from the motor case through the bypass flow passage, instead of through the gap between the earth conductor and the rotor shaft that provides larger flow resistance, the advantage of controlling the electrical motor using an inverter without damaging the electrical conductor can be brought prominently.

In addition, it is preferable that a flow passage cross-sectional area of the bypass flow passage is made larger than a cross-sectional area of a gap between the frame and the rotor shaft.

In addition, it is preferable that the motor case has a cylindrical sealing member, a labyrinth seal is formed on an inner surface of the sealing member, cylindrical one end of the sealing member is fixed with the motor case, the rotor shaft is inserted into the sealing member, and the earth conductor is fixed with the motor case by being attached to cylindrical another end of the sealing member.

In addition, it is preferable that the bypass flow passage is formed as a groove on at least one of the frame of the earth conductor and the motor case at a joint surface of the frame and the motor case.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a cross-sectional view of an electrical motor according to an embodiment;

FIG. **2** is an enlarged cross-sectional view showing a featured portion of the electrical motor;

FIG. **3** is a cross-sectional view of a sealing member of the electrical motor;

FIG. **4** is a front view of the sealing member; and

FIG. **5** is front view of an earth conductor of the electrical motor.

DESCRIPTION OF EMBODIMENT

An electrical motor **1** according to an embodiment will be explained with reference to the drawings. The electrical motor **1** is an alternate current motor, and includes a motor case **10**, a stator **20** and a rotor **30** as shown in FIG. **1**.

The motor case **10** is configured of a circumferential wall **11**, and an end wall **12** and a pass-through wall **13** that close both ends of the circumferential wall **11**. An inner space **14** is formed inside the motor case **10** (the circumferential wall **11**, the end wall **12** and the pass-through wall **13**). The stator **20** is disposed on an inner circumferential surface of the circumferential wall **11**. The stator **20** is configured by winding coils around a cylindrical stator iron core **21**.

A support cylinder **12***a* is protruded from the center of the end wall **12** toward the inner space **14**. A ball bearing **40**A and a sealing end member **50**A are attached to an end of the support cylinder **12***a*. On the other hand, a cylindrical hole **13***a* is formed at the center of the pass-through wall **13**. A roller bearing **40**B and a cylindrical sealing member **50**B are attached to the cylindrical hole **13***a*. In addition, after-explained refrigerant gas can flow through the roller bearing **40**B. Note that the sealing members **50**A and **50**B are formed of electrically conductive material (metal). Therefore, in view of electricity, the sealing members **50**A and **50**B can be regarded as portions of the motor case **10**.

Each of the sealing members **50**A and **50**B has an almost cylindrical shape, and is provided with a labyrinth seal **52** (see FIG. **2** and FIG. **3**) configured by plural annular protrusions **51** each of which is formed on an inner surface thereof and has an almost triangle cross-sectional shape. A wall-side end **53** of the sealing end member **50**A is fixed with the support cylinder **12***a* with no gap. Similarly, a wall-side end (cylindrical one end) **54** of the cylindrical sealing member **50**B is fixed with the cylindrical hole **13***a* with no gap.

In addition, as shown in FIG. **2**, an earth conductor **60** is fixed, by screws **63**, with an end (cylindrical another end) **55** of the cylindrical sealing member **50**B on a side of the inner space **14**. Note that exact positions of the screws **63** are indicated by screw holes **64***a* in FIG. **4** and screw holes **64***b* in FIG. **5**. The earth conductor **60** includes an annular conductive frame **61** as shown in FIG. **5**, and many fiber-like conductors (electrical conductors: conductive brush) **62** extended inward from an inner circumferential surface **61***a* of the annular conductive frame **61**. When a rotor shaft **32** is inserted into the earth conductor **60** and the cylindrical sealing member **50**B, ends of the fiber-like conductors **62** are contacted with an outer circumferential surface of the rotor shaft **32**.

The rotor **30** is configured of a cylindrical rotor coil **31** and the rotor shaft **32**. The rotor coil **31** is configured by winding coils around a cylindrical iron core. The rotor shaft **32** is inserted-into and fixed-with the rotor coil **31**. In addition, the rotor **30** is rotatably supported by the end wall **12** and the pass-through wall **13** with the bearings **40**A and **40**B interposed therebetween and with the rotor coil **31** located inside the stator **20**.

As shown in FIG. **3** and FIG. **4**, bypass flow passages **56** are formed, as grooves, on a joint surface of the end **55** of the cylindrical sealing member **50**B with the earth conductor **60**. Note that the bypass flow passages may be formed, as grooves, on the earth conductor **60**. Alternatively, they may be formed on both of the cylindrical sealing member **50**B and the earth conductor **60**. By forming the bypass flow passages on the joint surface as grooves, the bypass flow passages can be formed by easy workings.

Here, a total cross-sectional area (total flow passage cross-sectional area) of the bypass flow passages **56**, viewed from an axial direction of the rotor shaft **32**, is made larger than a cross-sectional area of a gap where the fiber-like conductors **62** are disposed (gap between the annular conductive frame **61** and the rotor shaft **32**). Namely, flow resistance through the bypass flow passages **56** is smaller than flow resistance through the gap where the fiber-like conductors **62** are disposed (gap between the annular conductive frame **61** and the rotor shaft **32**).

In addition, the electrical motor **1** is provided with cooling flow paths **15** as a cooling mechanism. The cooling flow paths **15** is paths through which refrigerant supplied from the outside of the electrical motor **1** circulates in the motor case **10**. The cooling flow paths **15** are formed between the circumferential wall **11** and the stator iron core **21**. The refrigerant liquid supplied from the outside cools the stator iron core **21** while flowing through the cooling flow paths **15**, and some of the refrigerant liquid becomes refrigerant gas. The refrigerant that has cooled the stator iron core **21** is discharged, in a gas-liquid mixed state, to a side of the end wall **12** in the inner space **14** to cool a coil end **22**. Almost all of the refrigerant that has cooled the coil end **22** becomes refrigerant gas.

Due to change from the refrigerant liquid to the refrigerant gas, pressure in the side of the end wall **12** in the inner space **14** rises, and the refrigerant gas moves to a lower-pressure side of the pass-through wall **13** in the inner space **14** through a gap between the stator iron core **21** and the rotor coil **31**. The refrigerant gas that has moved into the side of pass-through wall **13** in the inner space **14** is discharged to a refrigerant circulation passage outside the motor case **10** through a discharge port (not shown) provided on the motor case **10**. In addition, the refrigerant gas that has moved into the side of pass-through wall **13** in the inner space **14** flows out to a lower-pressure outside of the motor case **10** through the bypass flow passages **56** and a flow passage **70** (see FIG. **2**) outside the roller bearing **40**B. Note that the refrigerant gas flow through not only the flow passage **70** outside the roller bearing **40**B but also through the roller bearing **40**B itself.

As explained above, the inner pressure in the motor case **10** rises higher than the outside pressure due to the change from refrigerant liquid to refrigerant gas, and thereby the refrigerant gas flows out from the motor case **10** through the flow passage **70** outside the roller bearing **40**B. In this regard, the refrigerant gas doesn't flow through the fiber-like conductors **62** but through the bypass flow passages **56** before it reaches the flow passage **70** outside the roller bearing **40**B. Therefore, the refrigerant gas hardly flows through the fiber-like conductors **62**, so that it doesn't damage the fiber-like conductors **62** and electrical charge remained in the rotor shaft **32** (shaft current) can be eliminated stably via the fiber-like conductors **62**.

In addition, since the flow passage cross-sectional area of the bypass flow passages **56** is made larger than the cross-sectional area of the gap where the fiber-like conductors **62** are disposed (gap between the annular conductive frame **61** and the rotor shaft **32**), the refrigerant gas flows out from the motor case **10** through the bypass flow passages **56** that provide smaller flow resistance. Therefore, damages of the fiber-like conductors **62** can be further avoided and the electrical charge remained in the rotor shaft **32** (shaft current) can be eliminated more stably via the fiber-like conductors **62**.

Further, a small amount of the refrigerant gas may flows through the fiber-like conductors **62** but an refrigerant amount flowing out from the electrical motor **1** is reduced by disposing the earth conductor **60** at the end **55** of the cylindrical sealing member **50**B on a side of the inner space **14**, so that damages of the fiber-like conductors **62** can be further avoided and the electrical charge remained in the rotor shaft **32** (the shaft current) can be eliminated more stably via the fiber-like conductors **62**.

In addition, the bypass flow passages **56** can be formed on the cylindrical sealing member **50**B by relatively easy workings such as cutting work using an end mill or the like, and the bypass flow passages **56** never affects electrical charge elimination performance of the earth conductor **60**.

Note that, in the above embodiments, the earth conductor **60** includes the annular conductive frame **61** and is formed in an annular shape. However, the earth conductor is not limited to an annular shape. For example, the earth conductor may be formed in a curved shape such as a half-annular shape along part of an outer circumferential surface of the rotor shaft **32**, and can take various shapes.

In addition, in the above embodiment, the fiber-like conductors (electrical conductors) **62** are mounted thickly on the inner circumferential surface **61***a* of the annular conductive frame **61** of the earth conductor **60**. However, the electrical conductor(s) is not limited to a fiber-like member. For example, the electrical conductor(s) may be configured by a sheet-like member that is disposed on the inner circumferential surface **61***a* along the axial direction of the rotor shaft **32** so as to contact a surface of the sheet member with a surface of the rotor shaft **32**, and can take various shapes.

In addition, in the above embodiment, the refrigerant gas that has flown through the bypass flow passages **56** flows out from the motor case **10** through the flow passage **70** outside the roller bearing **40**B (and through the roller bearing **40**B itself). However, another flow passage(s) may be provided for the refrigerant gas other than the above-explained flow passage **70**.

What is claimed is:

1. An electrical motor comprising:

a motor case inside which an inner space is formed;

a bearing disposed so as to pass through a wall of the motor case;

a rotor shaft rotatably supported by the bearing; and

an earth conductor that is fixed with the motor case and includes a frame and an electrical conductor provided on the frame, wherein

the frame has an annular or curved inner circumferential surface along an outer circumference of the rotor shaft and is fixed with the motor case,

the electrical conductor is disposed on the inner circumferential surface of the frame so that an end of the electrical conductor is slidably contacted with the rotor shaft,

a bypass flow passage is provided between the earth conductor and the motor case, and

the inner space and an outside of the motor case are communicated with each other via the bypass flow passage.

2. The electrical motor according to claim **1**, wherein

the inner space is filled with higher-pressure gas than pressure outside the motor case.

3. The electrical motor according to claim **1**, wherein

a flow passage cross-sectional area of the bypass flow passage is made larger than a cross-sectional area of a gap between the frame and the rotor shaft.

4. The electrical motor according to claim **1**, wherein

the motor case has a cylindrical sealing member,

a labyrinth seal is formed on an inner surface of the sealing member,

cylindrical one end of the sealing member is fixed with the motor case,

the rotor shaft is inserted into the sealing member, and

the earth conductor is fixed with the motor case by being attached to cylindrical another end of the sealing member.

5. The electrical motor according to claim **1**, wherein

the bypass flow passage is formed as a groove on at least one of the frame of the earth conductor and the motor case at a joint surface of the frame and the motor case.

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